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Bar Charts and Milestone Charts

1.1 INTRODUCTION

In complex, interrelated business activities, the manager or the administrator constantly looks forward to those techniques or methods which help him in planning, scheduling, and controlling such activities. The concepts of network planning and critical path analysis have greatly assisted him. The network approach to action planning is a major advance in management science. It is a technique through which large projects are broken down to individual jobs or events and arranged in a logical network. These individual jobs are given time estimates for their execution, and the network helps in identifying those jobs or events which control the completion of the project.

PERT and CPM are two such management techniques or tools that have been accepted in recent years. PERT stands for Program Evaluation and Review Technique, and CPM for Critical Path Method. Both these tools define and coordinate various activities of a project and successfully accomplish the objectives on time. Various claims have been made as to how PERT or CPM has helped management in drastically reducing the project execution time. While such claims cannot be substantiated directly, these techniques have undoubtedly aided the management tremendously.

Some impressions have been created that network analysis is a solution to all bad management problems. This is far from being true. No management tool can make decisions. However, tools such as network analysis provide a management with additional information based on which better decisions can be made.

The network representation of projects or activities has its basis in *milestone charts* which are modified, improved versions of *bar charts*. While the latter are inadequate for large projects, they have their own merits when applied to fairly small projects. In this chapter, we shall discuss the bar charts, their adequacies and inadequacies, modifications to yield milestone charts, and, finally, their extension to networks.

1.2 GANTT CHARTS

In dealing with complex projects, a pictorial representation showing the various jobs to be done and the time and money they involve is generally helpful. One such pictorial chart, also known as the bar chart, was developed by Henry Gantt around 1900. It consists of two coordinate axes,

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one representing the time elapsed and the other, jobs or activities performed. The jobs are represented in the form of bars as shown in Fig. 1-1. The

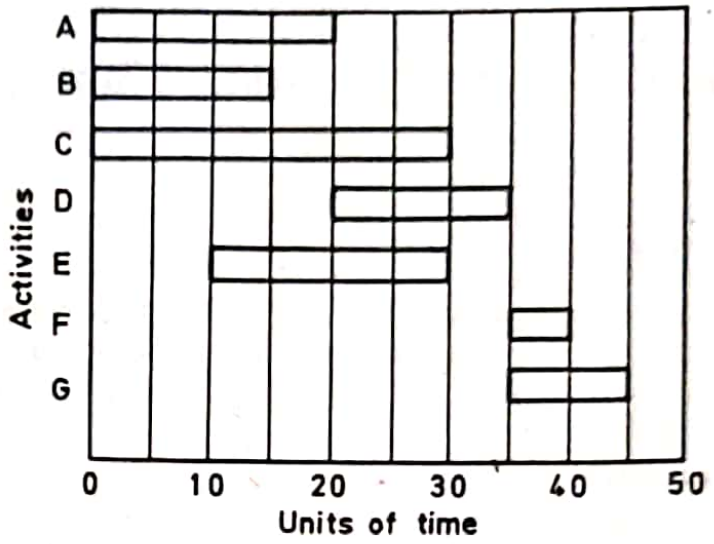

FIGURE 1-1

length of a bar indicates the duration the job or activity takes for completion. Generally, in any project, some jobs can be taken up concurrently and some will have to be completed before others can begin. Hence, in a bar chart representing a project, some of the bars run parallel or overlap each other time-wise (these correspond to concurrent jobs) and some run serially with one bar beginning after another bar ends (corresponding to an activity that succeeds a preceding activity). In Fig. 1-1, for example, activities *A*, *B*, and *C* can start at the same time and proceed concurrently or in parallel, though they take different time intervals for their completion. Activity *D*, however, cannot begin until activity *A* is over. The bars representing *A* and *D* therefore run serially.

Let us consider a specific example. A piece of equipment is made of two parts *A* and *B* which are to be assembled together before they are dispatched. Part *A* is of cast steel which requires a pattern and a mould. Part *B* is a machined item made on a special machine *M* which needs to be purchased and installed. Part *A* requires special heat-treatment before assembly. The assembly needs to be tested with a specially-constructed rig before dispatch. The time scale for each activity is as follows:

Preparing a pattern for casting	4 weeks
Preparing a mould	2 weeks
Casting and cleaning operation of *A*	1 week
Heat-treatment of *A*	2 weeks
Obtaining and installing machine *M*	7 weeks
Machining part *B*	5 weeks
Assembling parts *A* and *B*	3 weeks
Preparing the test rig	4 weeks

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Testing the assembly	2 weeks
Packing for dispatch	1 week

The bar chart for this project is shown in Fig. 1-2. The various activities are shown along the ordinate or vertical axis and the time elapsed along the horizontal axis. The chart is self-explanatory.

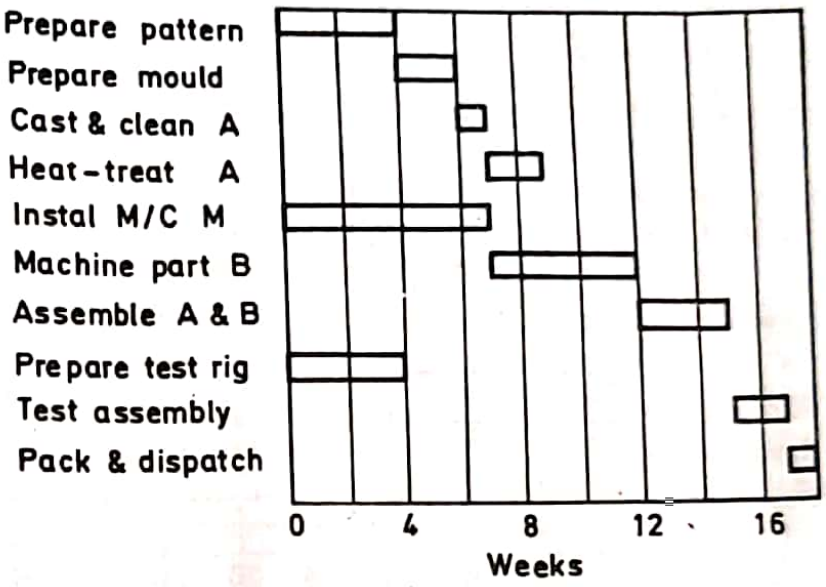

FIGURE 1-2

1.3 WEAKNESSES IN BAR CHARTS

The example in Section 1.2 was deliberately chosen to show that the bar chart may appear to be an excellent pictorial representation of a project. However, in practice, bar charts have serious limitations. A few of these are now described.

Interdependencies of Activities

In a programme where there are a large number of activities that can be started with a certain degree of concurrency, the bar chart cannot show clearly the interdependencies among the various efforts or activities. This is a serious deficiency. The mere fact that two or more activities are scheduled for simultaneous or overlapping times does not necessarily make them related or interdependent, or completely independent. Consider, for example, the project represented in Fig. 1-2. Such activities as preparing a pattern, preparing a mould, casting and cleaning, and heat-treating have to run sequentially, i.e., one activity must be completed before the other can begin. The bars representing these activities are not allowed to overlap. On the other hand, installing machine *M* and preparing the test rig can proceed simultaneously because they are completely independent activities, and hence the bars representing them can run parallel to each other. However, this is exactly the weakness of the bar chart, because two parallel bars need not necessarily stand for independent activities as the

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following example will show.

Suppose a project involves digging foundation, erecting side boards or shuttering, and pouring concrete. The time consumed is shown against each activity:

Digging foundation	20 weeks
Erecting side boards	14 weeks
Pouring concrete	16 weeks

If the activities are not allowed to run in parallel but in strict sequence, the total time taken for the completion of the project is 50 weeks. As we can easily see, the erection of side boards can start after the completion of, say, one-half of foundation digging. Similarly, the pouring of concrete can start, say, 5 weeks after the erection of side boards. The bar chart for these activities will be as shown in Fig. 1-3. According to this plan,

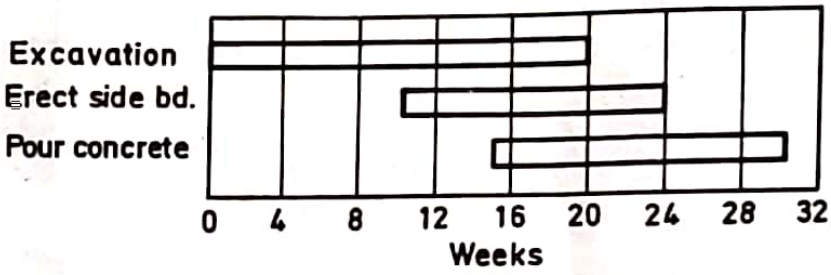

FIGURE 1-3

the side board erectors still have 4 weeks of work after the excavation job is over. However, if due to certain unexpected difficulties the excavation is delayed by 1 or 2 weeks, how will this reflect on the side board erection or the concrete pouring job? This is not revealed by the bar chart.

Project Progress

A bar chart cannot be used as a control device since it does not show the progress of work. A knowledge of the amount of work in progress or jobs completed is absolutely necessary in a dynamic programme. Changes in plans are a necessary part of a large project and a bar chart does not offer much assistance under such circumstances. However, a conventional bar chart can be modified to give this additional information as shown in Fig. 1-4. Suppose 16 weeks have elapsed after the project started; the progress made in the project can be depicted by partially filling in the blank bars. Foundation digging, according to Fig. 1-4, is 2 weeks behind schedule.

Uncertainties

A bar chart does not reflect the uncertainty or tolerances in the duration times estimated for various activities. The modern-day space system pro-

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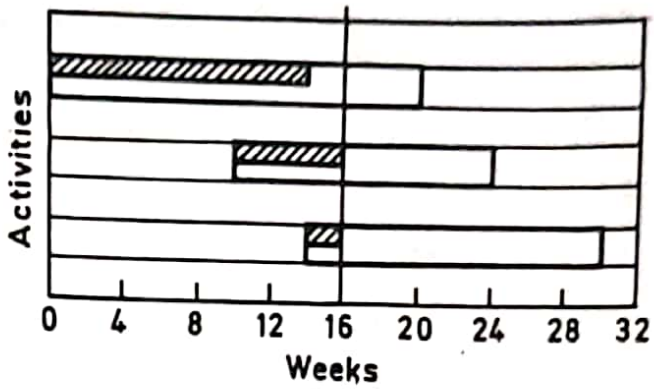

FIGURE 1-4

grammes or other complex projects are largely characterized by extensive research, development, and technological progress. The traditional knowledge or practices play a very insignificant role. In such situations, the completion of various stages or jobs cannot be forecast with exactness. The uncertainty about a test becoming successful, or a sudden breakthrough in technology or know-how will always provide situations which will make rescheduling of various events a necessary part of the project and give it a dynamic character which is not reflected in a bar chart.

1.4 MILESTONE CHARTS

Because of the shortcomings or the inadequacies of the bar chart in meeting the requirements of the modern-day management, efforts have been made to modify it by adding new elements. One such modification was discussed in Section 1.3 under "Project Progress" with reference to Fig. 1-4. Another important modification, relatively successful, has formed a link in the evolution of the Gantt chart into the PERT or CPM network. This modification is called the *milestone system.*

Milestones are key events or points in time which can be identified when completed as the project progresses. In the Gantt chart, a bar which represents a long-term job is broken down to several pieces, each of which stands for an identifiable major event. Each event is numbered and an explanatory table given, identifying the number with the event. These are specific events (points in time) which a management has identified as important reference points during the completion of the project. This work breakdown increases the awareness of the interdependencies between tasks.

Figure 1-5 shows a Gantt chart and Fig. 1-6 the corresponding milestone chart. Two important points to be noticed are that (a) the long-time jobs are identified in terms of specific events or milestones, and (b) these milestones or key events are plotted against the time scale, indicating their achievements by specified dates.

While the milestone chart was definitely an improvement on the bar chart, it still had one great deficiency, i.e., it did not clearly show the

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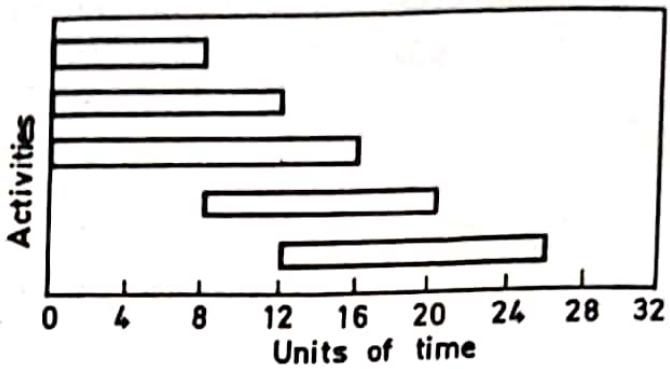

FIGURE 1-5

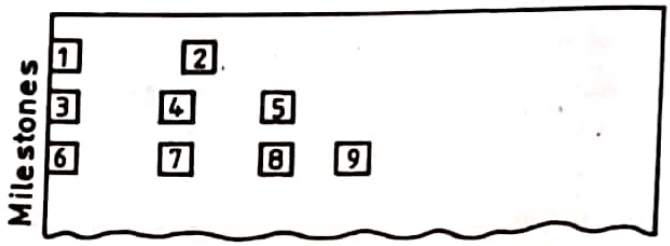

FIGURE 1-6

interdependencies between events. In a milestone chart, the events are in chronological, but not in a logical, sequence. A natural extension of the milestone chart was the network, where the events are connected by arrows in a logical sequence. This is shown in Fig. 1-7.

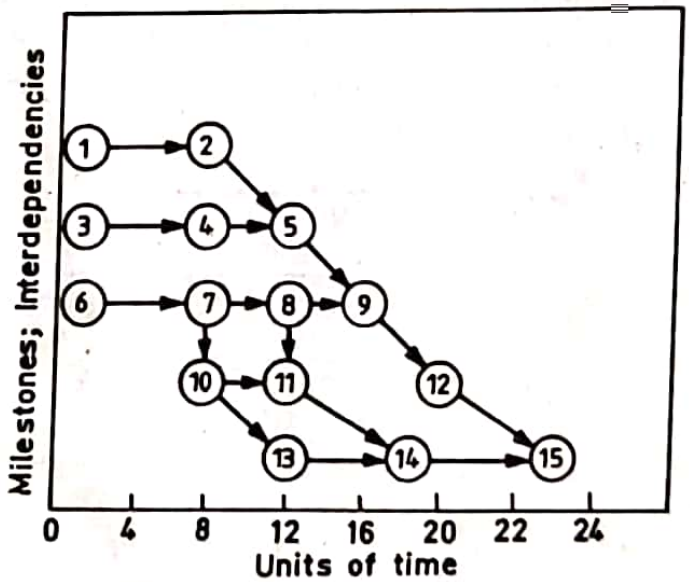

FIGURE 1-7

1.5 WORK BREAKDOWN STRUCTURE

The milestone charts bring into picture the functional elements of a programme and their interrelationship. This is achieved through what is

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known as the *work breakdown structure* or *indenture level structure*. Such a structure establishes the hierarchical order in a system. For example, the final assembly can be broken down as shown in Fig. 1-8. In the general case, a system is broken down to sub-systems and each sub-system to sub-sub-systems every one of which in turn reduces to major components, minor components, and so on. The breakdown is continued until the assembly is reduced to elements or components representing manageable units for planning and control.

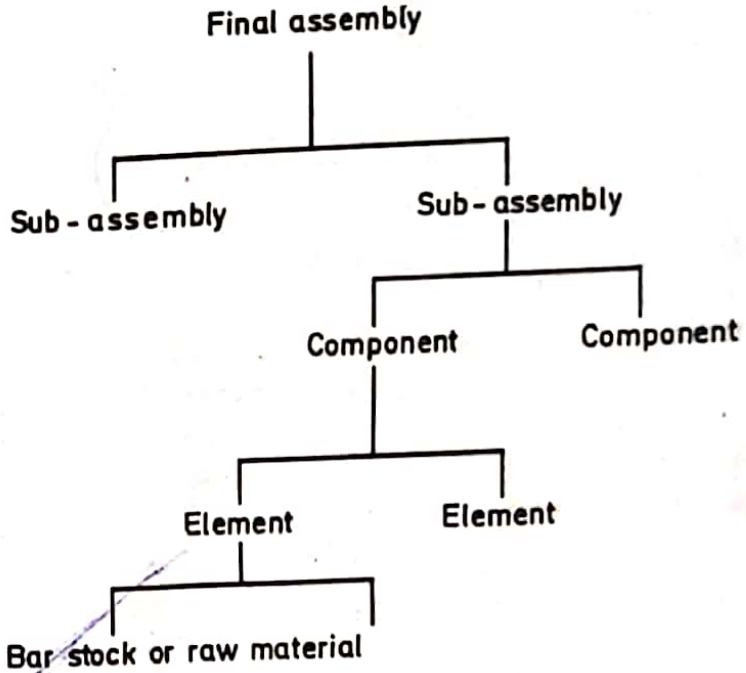

FIGURE 1-8

The several units in the breakdown could be either end-item oriented or product oriented. The end-item oriented units are the ones which form a necessary part of the final item. These could be like a transmitting system or a control unit in the final deliverable system. The product oriented units include organizational or service units which are also essential for the completion of a project. Each unit, whether product oriented or end-item oriented, must be definable segments of the work to be accomplished, and should form key points, each with a time schedule for satisfactory completion of the entire project.

1.6 CPM AND PERT NETWORKS

From the milestone chart and the work breakdown structure, there is a sort of continuity to CPM and PERT networks. There are two basic elements in a network plan. These are the activity and the event (similar to a milestone). The activity stands for the time-consuming part of a project. It represents a job. The event, also called a *node*, on the other hand, is either the beginning or the end of a job. The activities are denoted by arrows, and the events by circles or rectangles. When all

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activities and events in a project are connected logically and sequentially, they form a network. Such a network is the basic document in a network-based management system. Figure 1-9 shows how the events are connected by activities.

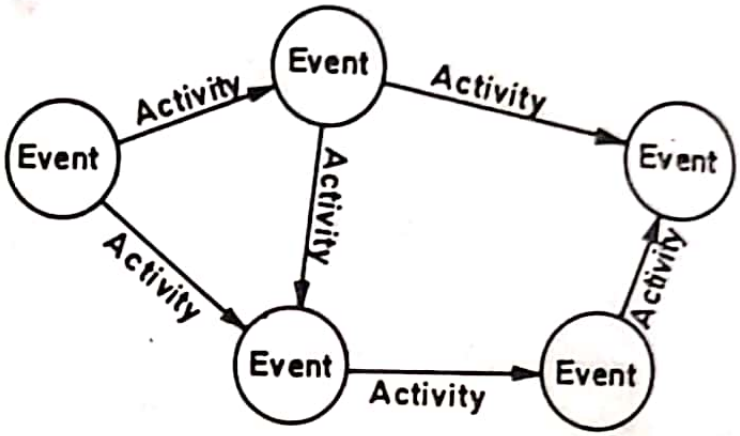
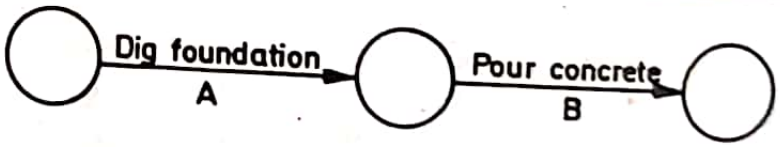


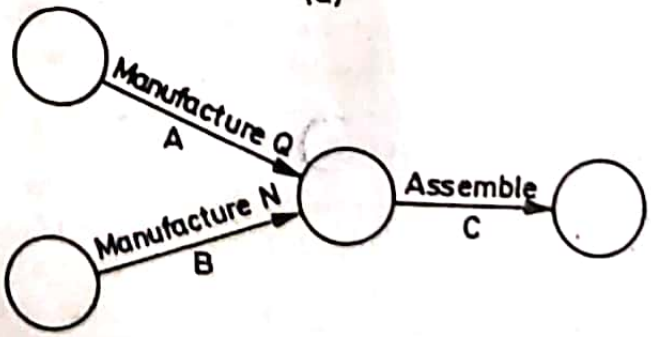
FIGURE 1-9

Some jobs can be taken up concurrently. In some cases, a job cannot be undertaken until another job is over. For example, if concrete pouring requires that foundation digging be complete, then job *A* representing digging will have to precede job *B* which represents the pouring of concrete (Fig. 1-10a). A few ways of representing concurrent jobs are shown in Figs. 1-10b and 1-10c. Figure 1-10b might represent: *A*—manufacture part *Q*; *B*—manufacture part *N*; *C*—assemble *Q* and *N*. Can you give an example for Fig. 1-10c?

In a network-based management system, the stress could be laid either on the event or on the activity. A difference between the PERT network and the CPM network is that one is event-oriented and the other activity oriented. The CPM (Critical Path Method) analysis is activity oriented as



(a)



(b)

FIGURE 1-10 (*cont.*)

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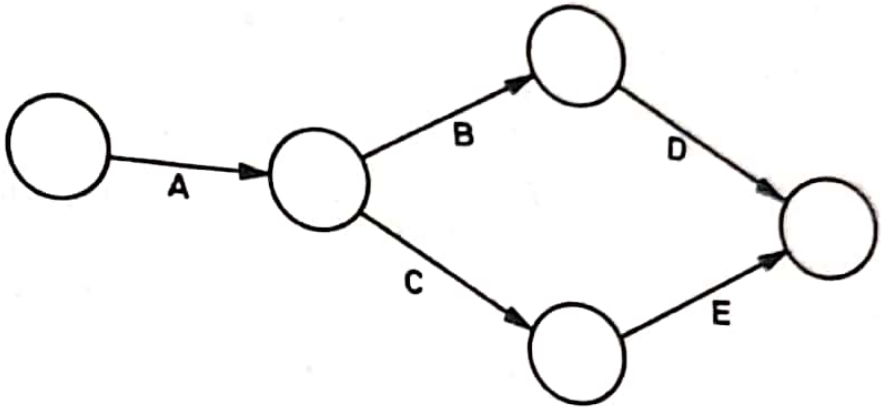

(c)

FIGURE 1-10

shown in Fig. 1-10 (a, b, and c). PERT (Program Evaluation and Review Technique) is event oriented. Figure 1-11 gives an example of a network that is event oriented. Here, the interest is focused upon the start or completion of events rather than on the activities themselves. The activities that take place between the events are not specified.

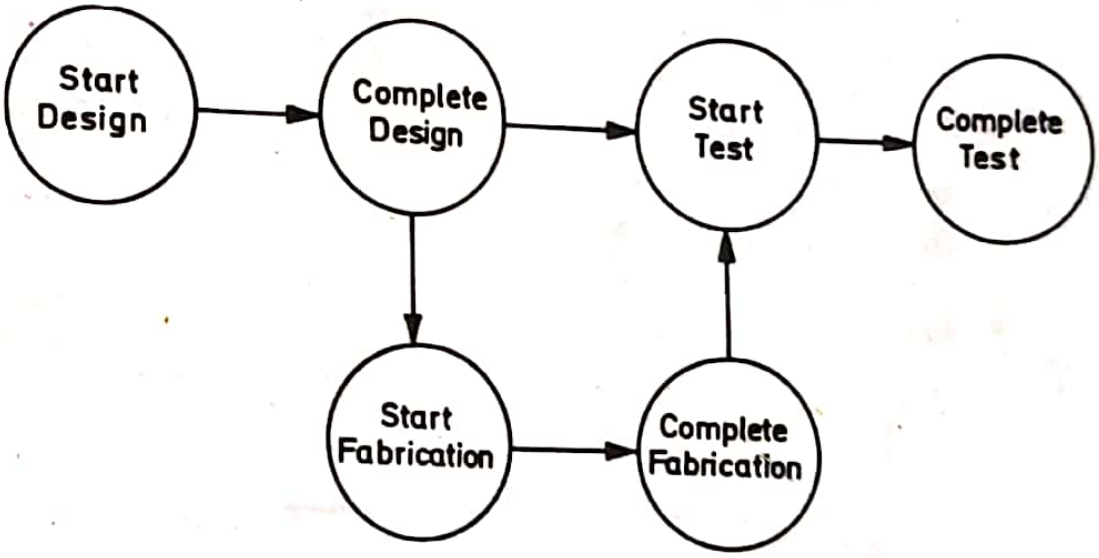

FIGURE 1-11

A few more differences exist between the CPM and PERT type of networks. For example, in a CPM-based network analysis, no allowance is made for the uncertainties in the duration of time involved. Further, in CPM, times are related to costs. However, the distinction between these two types of networks is diminishing. With minor modifications, both have given rise to several other programmes such as PEP (Program Evaluation Procedure), LESS (Least Cost Estimating and Scheduling), and SCANS (Scheduling and Control by Automated Network Systems). In subsequent chapters, we shall first consider the PERT network system and then the CPM system. Such a separate discussion, we hope, will reduce confusion and also aid in emphasizing several points which are common to both.

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QUESTIONS

1 What are Gantt charts and what are their weaknesses?

2 In what specific ways are milestone charts superior to bar charts? How is a network superior to a milestone chart?

3 What do you understand by a work breakdown structure?

4 What is meant by product oriented units and end-item oriented units in a work breakdown structure?

5 Explain clearly the difference between an activity and an event.

6 In what three major ways does a CPM network differ from a PERT network?

PROBLEMS

1 Represent on Gantt charts the following projects, the activities and their durations being as indicated:

(a) Conducting an examination

Design questionnaire	7 days
Print question paper	2 days
Distribute to various centres	4 days
Answer questionnaire	1 day
Collect answer books at main office	4 days

(b) Making prints

Make free-hand sketches	2 days
Make dimensioned scale drawings	4 days
Make prints	2 days
Cut and fold	1 day

(c) Making a chair (concurrent jobs)

Make dimensioned sketches of parts	2 days
Make legs	3 days
Make seat	2 days
Make back	2 days
Assemble parts	3 days

(d) Holding a conference (concurrent jobs)

By mail ask members for suitable dates	6 days
Inform date to members	2 days
Prepare agenda	3 days

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Arrange conference room	2 days
Arrange tea	1 day

2 The following project is to be represented by a bar chart. The duration for each activity is in days. These are the actual work-days. The project commences on Wednesday, November 15, with five work-days a week. Draw the bar chart with the horizontal scale denoting calendar dates.

Activity 1	8 days
Activity 2	4 days
Activity 3	7 days
Activity 4	9 days
Activity 5	3 days
Activity 6	3 days
Activity 7	14 days
Activity 8	17 days

Activities 1 and 2 can occur concurrently. Activity 3 can take place after activity 2 is completed. Activities 4, 6, and 3 can occur concurrently. Activity 8 can start 4 days after the commencement of activity 6. Activity 7 should follow activity 5. Activity 5 can begin concurrently with activity 8.

3 Referring to Problem 2, answer the following:

(a) On what calendar date can we expect the project to be completed?

(b) On December 3, what is the progress report?

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